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EFFECTS OF CONCENTRATE AND MINERAL SUPPLEMENTATION ON THE MINERAL STATUS AND PERFORMANCE OF A BEEF BREEDING HERD

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Effects of Concentrate and Mineral Supplementation on the Mineral Status and Performance of a Beef Breeding Herd

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An abstract of the thesis presented to the Senate of Universiti Pertanian Malaysia in partial fulfilment of the requirements for the Degree of Master of Science.

EFFECTS OF CONCENTRATE AND MINERAL SUPPLEMENTATION ON THE MINERAL STATUS AND PERFORMANCE OF A BEEF BREEDING HERD

by

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September, 1985

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Two experiments were conducted in Pahang, Malaysia. In Experiment 1, 175 Droughtmaster cows with nursing calves. were randomly assigned to four treatments: (1) phosphorus mineral block (PMB) + salt + concentrate (conc.); (2) PMB + salt; (3) Dicalcium phosphate (DCP) + salt + conc.; and (4) salt + conc. In Experiment 2, 193 cows were randomly assigned to four treatments: (1) Mineral meal (MM) + 0.68 kg conc.; (2) MM + 1.36 kg conc.; (3) salt only; and (4) MM only. Criteria for evaluation were P, Ca, Mg, K, Cu, Fe and Zn content of blood, forage and soil samples. Reproductive performance and body weight changes were also recorded.

The trend for blood plasma minerals in Experiment 1 was a general decline initially followed by an increase towards the end of the trial for Ca, Mg and K. An increase in Fe and Cu was

initially observed, followed by a decline. Zinc plasma levels declined throughout the experiment. The blood profile in Experiment 2 indicates deficiencies in plasma Mg, Fe and Cu.

Soil pH values ranged from 5.0 to 6.9 in Experiment 1 and 4.0 to 6.9 in Experiment 2. Soil extractable macroelements were adequate to meet the requirements of forages, except for P in both experiments. Macroelements in forages appear to be adequate, but some samples may be borderline for Cu and Zn in Experiment 1. Improvement in cattle productivity from mineral supplementation reflected mineral deficiencies in forages.

Pregnancy rates were favourably affected by concentrate supplements in Experiment 1. Percentage calf crop and calf crop weaned were likewise affected. Birth weights and calf weaning weights were highest in Groups supplemented with minerals.

Results from Experiment 2 suggests that concentrates did not enhance pregnancy rates, but calf crop was improved. Birth weights, percentage calf crop weaned and weaning weight were improved with mineral supplementation.

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EFFECTS OF CONCENTRATE AND MINERAL SUPPLEMENTATION ON THE MINERAL STATUS AND PERFORMANCE OF A BEEF BREEDING HERD

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Dua percubaan telah dijalankan di ladang lembu daging swasta di Pahang, Malaysia. Pada Percubaan 1, sejumlah 175 lembu betina Droughtmaster yang sedang merawat anak-anak lembu telah dibahagikan secara rawat ke empat perlakuan: (1) fosforus mineral block (PMB) + garam + konsentrat (conc); (2) PMB + garam; (3) Dikalsium fosfate (DCP) + garam + conc.; dan (4) garam + conc. Pada Percubaan 2, sebanyak 193 lembu betina telah dibahagikan secara rawat ke empat perlakuan; (1) Tepung mineral (MM) + 0.68 kg conc. (2) MM + 1.36 kg conc.; (3) garam sahaja dan (4) MM sahaja. Kriteria untuk penilaian adalah kandungan P, Ca, Mg, K, Cu, Fe dan Zn dalam sampel darah, rumput dan tanah. Prestasi reproduksi dan pertukaran berat badan pada lembu betina dan anak lembu telah direkodkan.

Dalam Percubaan 1, paras-paras Ca, Mg dan K menurun pada peringkat awal dan meningkat pada akhir-akhir percubaan. Kenaikan Fe dan Cu mulai diperhatikan pada permulaan diikuti dengan penurunan pada akhir percubaan. Kandungan Zn menurun pada keseluruhan jangkamasa

kajian. Dalam Percubaan 2 gambaran plasma darah menunjukkan kekurangan Mg, Fe dan Cu.

pH tanah berjulat antara 5.0 dan 6.9 dalam Percubaan 1 dan 4.0 hingga 6.9 dalam Percubaan 2. Makroelement yang diekstrak dari tanah melainkan P adalah mencukupi untuk memenuhi keperluan rumput. Keseluruhan unsur makro dalam rumput nampaknya mencukupi kecuali untuk beberapa sampel di mana kadar Cu dan Zn hampir mencukupi. Pembaikan pengeluaran lembu dari penambahan mineral menandakan kekurangan mineral dalam rumput. Kadar kebuntingan nyata dipengaruhi oleh pemberian konsentrat pada Percubaan 1. Peratus kelahiran dan anak cerai susu juga dipengaruhi oleh konsentrat. Berat lahir dan berat masa cerai susu didapati tertinggi dalam kelompok yang diberi mineral.

Keputusan dari Percubaan 2 menunjukkan bahawa konsentrat tidak mempengaruhi kadar kebuntingan sedangkan jumlah anak lahir menambah baik. Berat lahir, peratus anak lahir dicerai susu bertambah baik dengan permberian mineral.

CHAPTER 1

INTRODUCTION

Though an estimated 68% of the world's ruminant population is raised in developing countries, they account for only one-third of the meat production and 20% of the milk production (Rao, 1978). Sheer numbers alone means nothing; unproductive animals in fact would be in effect, free loaders on the nation's feed trough (Madamba, 1982). Low productivity, which is a characteristic of animal agriculture in the tropics, is due to many reasons, the most significant being the low feed intake and poor nutrition. This subsequently leads to poor growth rates followed by low reproductive performance characterized by first calving at 4-5 years of age with a calf in alternate years only. This is the most important factor limiting cattle production in developing countries (McDowell, 1976). Reproductive failure, thus is a consequence of inadequate nutrition and the extent of this failure depends upon the degree that it is lacking. Little (1973) regards reproductive failure as a protective mechanism; the pregnant animal subjected to this condition is committed to producing a calf, less committed to producing sufficient milk to rear it and definitely not committed to commence the cycle afresh.

Low rate of nutrition, by promoting low rates of growth, delay the occurance of puberty. An increase in fertility due to an increase in body weight has been demonstrated in the breeding ewe (Coop, 1962). Ward (1968) showed that for the Mashona breed of cattle in Rhodesia, there was a minimum liveweight range (270-295 kg) below which they could not conceive. For Merino sheep this minimum weight is about 36 kg (Laing, 1971). It is evident that there is a critical weight, probably varying with the breed, below which breeding will not occur. This relationship between nutrition and reproduction has led to the concept of the critical body weight below which an animal will not exhibit oestrus and conceive and above which it will (Lamond, 1968, 1970; Ward, 1968; Donaldson and Takken, 1968; Baker 1968).

The mechanism by which the loss of body weight hampered conception was elucidated by Symington and Scott (1967). They found that when cows lost 25-30% of their mature body weight, cyclic ovarian activity ceased, implying that the ability of the pituitary gland to produce gonadotrophins is impaired during malnutrition. The hypothalamus is now known to have basic control of the oestrus cycle through gonadotrophin releasing hormone (GnRH) which influences the pituitary gland. Nutritional stress from low ene

release and hence ovarian activity (Campbell, 1980). Lamond (1970), taking into account his own and Ward's work, proposed that each cow, according to her physiological status, has a high probability of conception within a certain range of body weights. Accordingly, the three innovations chosen to help improve productivity has been listed in order of importance as follows: feeding, management and breeding. Live weight of livestock should be improved first followed closely by improved management; only then benefit would be derived from genotype (McDowell, 1966). For field studies, body weight and its changes appear to be the most useful criteria on which to assess the ultimate effects of variations in nutrition (Little, 1973).

On the other hand, there is much evidence to show that over-feeding may be inimical to efficient reproductive performance. This has been neatly summarized by Pope (1967)......"once a beef female meets her needs for optimum growth and production, superabundant feed may become a liability".

The levels of the macroelements in the various raw material are relatively well-known since they are easy to determine and their variability is generally not great, but for the microelements, their levels in raw materials are extremely variable and depend on many factors, such as, soil composition, fertilization, rainfall and so on. Besides, animal requirements are still not accurately known (animal feeding: energy, amino-acids, vitamins, minerals. AEC. Document 4, France).

Malaysia is only 65% self-sufficient in beef and 5% in milk and milk products (Noordin Keling, 1980). However, the Government of Malaysia aims for the country to be fully self-sufficient in meat and 20% self-sufficient in dairy products by 1990 (Osman Din, 1980). But, unless some of the problems and constraints identified by Syed Ali (1980) which includes: (i) that, indigenous ruminants are not so productive in terms of meat and milk products; (ii) low fertility and calving percentage, and (iii) non-availability of genetic materials for improvement of local breeds can be overcome, cattle productivity cannot be increased dramatically. This stated aim of 100% self-sufficiency in beef production must depend on the development of large scale farms such as Pahangbif. However the slow and modest returns as contrasted to the large sums involved in running a commercial beef enterprise, will make this venture unattractive to the private sector.

A study was carried out at a commercial beef herd of Pahang, in South Malaysia. The objectives were to investigate the effects of mineral and concentrate supplementation on the performance of a Droughtmaster breeding herd experiencing a decline in the calf crop.

CHAPTER 2

LITERATURE REVIEW

The most significant reason for low animal productivity in wet tropical countries is inadequate nutritional levels, particularly that of minerals.

Calcium and Phosphorus

Calcium (Ca) and phosphorus (P) are considered together because they are very closely related to the extent that a deficiency or an over-abundance of one may very likely interfere with the proper utilization of the other (Thompson, 1976). They are vitally concerned with not only bone development, together with vitamin D, but also growth and productivity, and essentially all important metabilic processes.

The requirements of these elements are dependent on the concentrations of each other. A narrow Ca:P ratio of 1:1 to 2:1 is usually recommended by the NRC (1976). For young calves and growing stock, the NRC recommends a Ca to P ratio of about 1.4 parts of Ca to 1 part of P. As cattle grow older and their skeletons are more developed, the Ca requirement is reduced slightly while P demands increase. This is due to larger body size with about 20% of the body phosphorus ratio being located in the body tissues and fluids. Mature animals should have a 1.1 to 1.0 Ca to P ratio in their daily ration whilst that of nursing cows should approximate 1.3 parts Ca to 1 part P due to the heavy lactation demand on calcium. In general, a close ratio is more critical when P intake is marginal or inadequate, while wide ratios increase the requirements of P and vitamin D. This balance is, therefore, often upset when legumes with a Ca/P ratio of 6:1 are fed to cattle. With ratios wider than 7:1, the efficiency of P absorption could be reduced (Underwood, 1966). Similarly, when mature tropical forages particularly low in P are grazed during extended dry seasons, an imbalance can result. However, feeding of P supplementation alone in the dry season when the animals are in the process of losing weight can create nutritional imbalances. There is a negative response to dry season P supplementation (Van Schalwyk and Lombard, 1969) because phosphorus is not the first limiting nutrient then. Other nutrients such as nitrogen and energy are as deficient and more critical under such conditions. Animals in a state of negative nitrogen and/or energy balance must have an extremely low P requirement so that its supplementation could create nutritional imbalances (Van Niekerk, 1976). Nevertheless, such supplementation during periods of weight loss could conceivably be important in the case of reproducing females, for a significant P carry-over effect has been demonstrated by Van Schalwyk and Lombard (1969). Therefore, P reserves can be built up which can benefit these animals during subsequent periods of rapid growth during the wet season, for then, P must be the most important limiting factor. This has been illustrated by the inability of energy (Lyle, 1970) or protein supplementation by themselves (Van Niekerk and Muir, 1970; Lyle, 1970) to have any significant effect on improving weight-gains then.

Phosphorus deficiency is the most widespread and economically important mineral problem affecting grazing ruminants throughout the world. In tropical countries, this is the most severe mineral limitation to grazing cattle with over 35 countries reporting such a situation (McDowell, 1976) including Malaysia (Hill and Rajagopal, 1962). The most devastating economic result of such an insufficiency is reproductive failure which causes invariably large losses to the cattle industry. Inhibition of the oestrus cycle has been reported by Hignett and Hignett (1952) to be due to various types of ovary dysfunctions resulting in the inhibition, depression or irregularity of oestrus. Thus, conception is delayed or prevented (Snock, 1964). Under conditions of extreme P deficiency, cattle may

or even coming into oestrus (Phillips, 1965). In a P deficient area, if a calf is produced, cows may not come into a regular oestrus until body P levels are restored, either by feeding a P supplementation or by cessation of lactation. This anoestrus has, however, been considered to be due to a combination of a P and a protein insufficiency since both nutrients are generally in short supply in mature tropical forages. Other problems associated with a P deficiency in range cattle include: a lowered conception rate and smaller calf crop; more difficult calving; lowered milk production accompanied by a subsequent lowered weaning weight of calves; reduced size and growth at a given age; and a poor appearance (Thompson, 1976).

Increased calving percentages from 20% to 50% were recorded when grazing animals in developing countries consume supplemental P (Bisschop and Groenewald, 1963; Ward, 1968; Brumby, 1974; Veiga, 1976). In a study in Rio Grande Do Sul, Brazil, involving 7,590 beef heifers and cows, 33.4% of all cows suckling a calf became pregnant when they received a small addition of bone meal, compared to 47.3% which received a larger amount. In the control group comprising of 2,511 animals receiving only a supplement of salt, only 25.6% of the lactating cows conceived (Grunet and Santiago, 1969). Guimaraes and Nassimento (1971) made a study on beef cattle to determine the effects of common salt, P, Ca, Cu and Co on the calving percentage. Three herds of about 50 cows and 2 bulls each, received a mineral supplement which consisted for the first herd of common salt, bone-meal, copper sulphate, and cobalt sulphate; for the second of common salt and bone-meal; and the third of just common salt. The fourth herd did not receive any supplement. The calving percentage in these four groups was 68.0, 72.2, 54.9 and 49.1%, respectively. The first two herds were significantly superior to the control group while the third group did not show any significant difference when compared to the control group. The authors concluded that bonemeal was the factor responsible for the increase in calving percentage and that copper, cobalt and common salt did not significantly affect it.

In experiments reported by Theiler _et al_. (1924), it was demonstrated that weaned calves, fed P, could gain 61 kg more weight over a 12-month period than unsupplemented controls. Likewise, young oxen gained 68 kg/year more than their controls while supplemented cows showed a weight advantage of 48 kg over a 11-month feeding period. Later, Bisschop and Du Toit (1929), demonstrated that by continuous P supplementation, 2½ year-old oxen had a 30% advantage over the controls, while bone-meal supplemented cows weighed 20% more and produced 30% more calves. Death losses amongst 139 bone-meal fed cows over a 40-month period amounted to only 10%, while 94% of the unsupplemented controls died during the experimental period. The beneficial effects of

P supplementation were subsequently confirmed by means of feed trials in Southern Africa (Kotz, 1963; Hurrell and Dugdale, 1958; Ward, 1968; Grant, 1975).

Weight gains were also favourably affected by P supplementation as shown in trials by Echevarria et al. (1973). The group in Peru obtained weight gains of 0.59 kg in steers supplemented with dicalcium phosphate and 0.27 kg for controls. There is also a tendency for live-weight gains to be increased in growing sheep with increasing P intake (Fishwick, 1978).

However, a P deficiency has not been clearly demonstrated in sheep fed forages low in P (McDonald, 1968). Although the bodies of these two species contain very similar concentrations of P, the feed intake per unit of bodyweight of sheep is 1.5 to 2 times more than that of cattle so that the former may require only half the concentration of P in their feed compared to the latter specie. Besides, sheep are very selective, foraging more for leaves which have a higher content of most elements.

The 1974 edition of the Latin American Tables of Feed Composition (McDowell et al., 1974) showed that in 48.4% out of 1,129 and 31.1% out of 1,123 forages samples, the average calcium and phosphoruous values were 0.2% or less and 0.3% or less, respectively. These values may be borderline to deficient for most classes of beef cattle. Besides, the availability of P in tropical grasses is frequently less than 50% (Butterworth, 1966; Playne, 1972). In general, forages tend to be higher in Ca and lower in P while the reverse is generally true in grains (Fick et al., 1976a). It is generally agreed that P concentration of 0.18% in roughage is adequate for beef cattle (Cohen, 1975; N.R.C., 1976). However, Little (1980) stated that 0.12% was adequate for growth of beef cattle up to 0.5 kg/day.

Low blood plasma P values in beef cattle has been observed in many developing countries. Underwood (1966) considered this criterion to be satisfactory for determining P values in animals and Duncan (1968) regarded low P levels to be the first indicator of a dietary P insufficiency. The measurement of blood inorganic P content provides the most readily determinable index of the P status of animals (Little et al., 1971). Conrad (1976) indicated that a decrease in serum inorganic P below normal levels of 6 mg% for adults and 6-8 mg% for young, to be an early sensitive biochemical measure of a P deficiency.

A significant correlation was observed between P values in blood serum and in grasses during a trial period of 14-21 months in cattle kept under range conditions in areas near Brazilia, Brazil, with the exception of severe P deficient areas. A close correlation was also found between increased rainfall and increased inorganic P in blood serum, with the above exception again (Dayrell et al., 1973). There is a significant fall in blood inorganic P with age (Gartner et al., 1966).

Serum inorganic P levels can be increased by supplementing cattle with bone-meal but the levels of calcium and also magnesium will be depressed (Reed et al., 1974) due to the formation of a colloidal calcium phosphate complex that is rapidly removed from the circulation (Irwing, 1973).

In many countries, large concentrations of iron, calcium and aluminium in the soil accentuates phosphorus deficiency by forming insoluble phosphate complexes. Normally, soils in the humid tropics are acidic with high percentages of exchangeable aluminium which form complex compounds with P, thus making it unavailable for plants (Woodruff and Kamprath, 1965). According to Menicucci Sobrinho (1943), a phosphorus deficiency occurs in cattle when the soil concentration is below 0.27% but does not occur if it is above 0.55%.

Phosphorus deficiency has been reported to result indirectly in death as a consequence of cattle developing botulism due to pica (Calvett et al., 1965; Tokarnia et al., 1970).

Calcium insufficiencies are rarely a problem among grazing cattle, except for high milk producing cows or those kept on pastures produced on acid and sandy soil in humid areas where the herbage consists mainly of quick-growing grasses with no legumes (Underwood, 1966). In fact, a Ca deficiency has not been reported in ruminants grazing native pastures even without legumes, but this condition can easily be produced in young growing animals and lactating dairy cows fed native pastures supplemented with concentrates (Loosli, 1976). Manifestations of the condition include decreased weight-gains, poor digestibility, low blood Ca levels, brittle bones and in some cases, tetany. However, when a Ca deficiency does occur, other insufficiencies such as low crude protein or phosphorus levels are likely to be primary (Langlands et al., 1967; McDonald, 1968). When cattle are fed on rice straw for extended periods, a Ca insufficiency arises, apparently due to large amounts of oxalates in this feed (Ray, 1963).

However, on the basis of low Ca levels in the blood of cattle and in forages, areas of Peru (Gomez et al., 1967; Echevarria et al. 1973), Venezuala (De Alba and Davis, 1957; French and Chaparro, 1960), Columbia (Vergara, 1967), Guyana (Underwood, 1966;

Holder, 1972) and a few other countries are considered to be deficient in this element.

Calcium levels in blood serum tend to remain constant regardless of high intakes or body losses because the parathyroid hormone can mobilize Ca from bones. As such, when Ca intake increases, Ca absorption will do likewise but Ca resorption will decrease so that the total Ca transport into the exchangeable pool remains fairly constant (Ramberg et al., 1976). The major process of Ca homeostasis is Ca resorption from bone. This is responsible for the long term control of Ca metabolism and in particular, for maintaining Ca reserves. In contrast, there is no direct mobilizing mechanism for phosphorus but since these two elements are combined in bone, the mobilization of Ca is accompanied by the incidental mobilization of P. Due to this reason, cattle depend on the meal-to-meal supply of P because even though the bone stores of P are large, an inadequate supply may quickly lead to biochemical and structural disturbances (Thompson, 1976).

Serum Ca levels in cows are not affected by complete mineral supplementation but seasonal fluctuations have been reported by Lebdosoekojo et al., (1980). He indicated that the levels at the beginning of the rainy season were higher than in the dry season.

In view of the critical role phosphorus and calcium play in animal feeds, it is important in the formulation of feeds to ensure that the proper levels of biologically available Ca and P are provided for the various ages and classes of livestock, keeping in mind the cost, for optimum performance (Thompson, 1976).

Magnesium

Much less is known about magnesium (Mg) requirements in ruminants and the factors which affect these requirements than those for phosphorus and calcium. The majority of evidence suggests that pastures or rations containing more than 0.07% Mg in the dry form ought to satisfy the minimum requirements for the growth of cattle and sheep and that the level of 0.17% is adequate for cows and ewes in lactation (Underwood, 1966; Minson and Norton, 1982). Under practical conditions, usually spontaneous deficiencies of Mg are considered improbable because there are few forages where the concentration is less than 0.1% (De Alba, 1973). However, Mg availability is reduced by a high diet of nitrogen and potassium or energy deficiencies (Martens and Rayssiguier, 1980).

Although Mg is essential for all species, the incidence of hypomagnesemia (grass tetany) has stimulated interest in the study of Mg for grazing ruminants. Symptoms of grass tetany were first described by Sjollema (1932). Since then, this condition has been reported in many countries such as Chile, Haiti, Honduras, Jamaica, Peru, Suriman, Uruguay (McDowell, 1976) and in Argentina (Ovejero, 1964; Culot and Fernandez Tunon, 1967).

Magnesemic tetany occurs principally in very productive pastures and in equally productive animals with elevated metabolic activity (De Alba, 1973). Higher productivity, for instance, of milk, may not be matched by higher levels of Mg needed for this increased production. This happens even though body reserves of Mg may be high, for this element is stored chiefly in bone and hence is only released slowly. As such, the sudden increased demand cannot be met, resulting in the plasma Mg levels falling to a critical level leading to tetany. Due to the above pre-condition necessary for its occurence, this condition has never been diagnosed in adult male cattle or in steers but in only a limited number of non-lactating cows and calves (Viana, 1976). In the latter, tetanous symptoms accompanied by low blood Mg levels develop in those calves reared too long on milk only, whilst in older cattle, susceptibility to this condition is increased due to their inability to mobilize skeletal Mg with increasing age (Blaxter and Sharman, 1955), though Gartner et al. (1966) found a significant increase of serum Mg with age.

Minyard and Dearborn (1965) presented in detail five experiments with cows during a period of 2 years in S. Dakota, U.S.A. on three different farms, which previously had produced tetany from their pastures. In each experiment, the herd was divided at random into two groups. One group received a calculated supplement to provide 6g of Mg and 12g of Ca/cow/day and the other remained as the control group with a similar supplement but without the Mg addition. The two groups in each experiment were placed in adjacent pastures that were considered similar in respect to the probable occurence of grass tetany. There occurred 18 cases of tetany in 505 cows in the control group compared to one case (this one being fatal) in 504 animals in the treated group.

According to Newton et al. (1972), sheep fed a diet high in potassium tended to excrete more Mg in their urine and faeces and also that high potassium levels interfered with Mg absorption. Elevated urinary Mg excretion, coupled with a lower retention, also occurred when sheep was fed high nitrogen (urea) diets (Moore et al., 1972). The conclusion arrived at was that grass tetany was produced under conditions that impaired the absorption of Mg or increased the excretion of Mg from the body.